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(54) **FLUIDIC OSCILLATOR HAVING DECOUPLED FREQUENCY AND AMPLITUDE CONTROL**

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F15C 1/22 (2006.01)

(52) **U.S. Cl.**
CPC ***B05B 1/08*** (2013.01); ***F15C 1/22*** (2013.01)

(58) **Field of Classification Search**
CPC B05B 1/08; F15C 1/22
USPC 239/589.1, 555, 11
See application file for complete search history.

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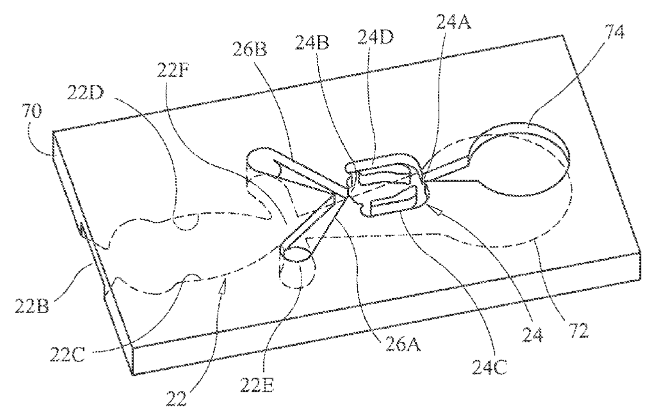
(57) **ABSTRACT**

A fluidic oscillator having independent frequency and amplitude control includes a fluidic-oscillator main flow channel having a main flow inlet, a main flow outlet, and first and second control ports disposed at opposing sides thereof. A fluidic-oscillator controller has an inlet and outlet. A volume defined by the main flow channel is greater than the volume defined by the controller. A flow diverter coupled to the outlet of the controller defines a first fluid flow path from the controller's outlet to the first control port and defines a second fluid flow path from the controller's outlet to the second control port.

10 Claims, 4 Drawing Sheets



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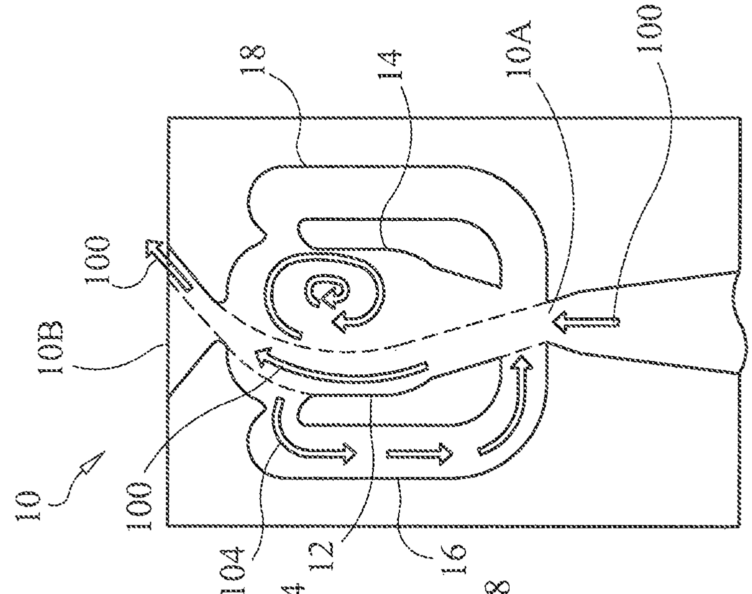


FIG. 1C
PRIOR ART

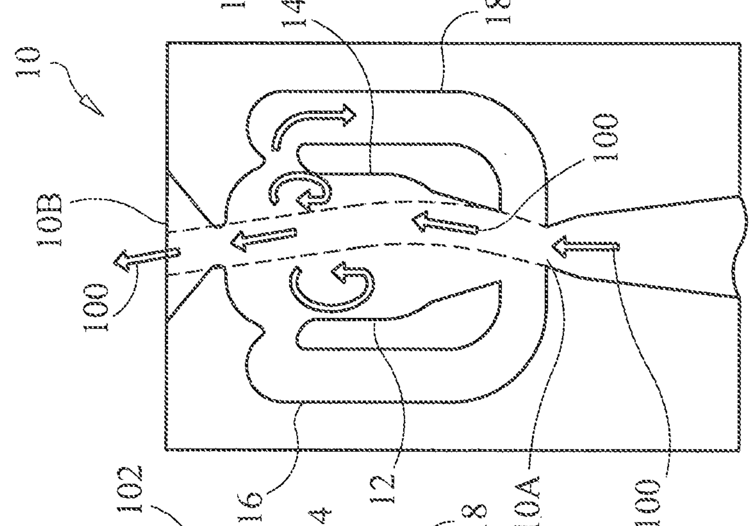


FIG. 1B
PRIOR ART

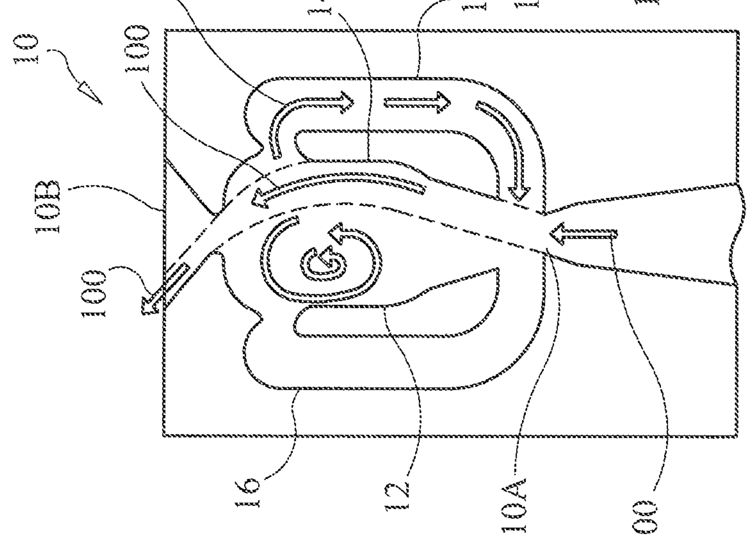


FIG. 1A
PRIOR ART

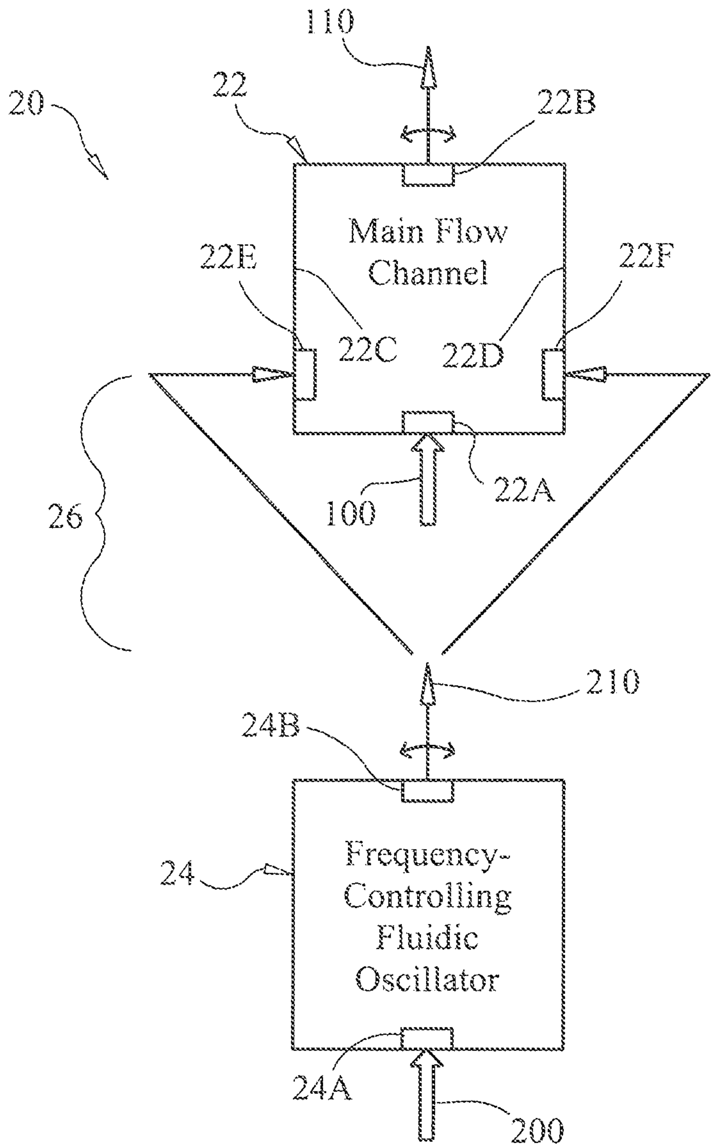

110
20
22
22B
Main Flow
Channel
22E
22F
22C
22D
26
100
22A
210
24B
24
Frequency-
Controlling
Fluidic
Oscillator
24A
200

FIG. 2

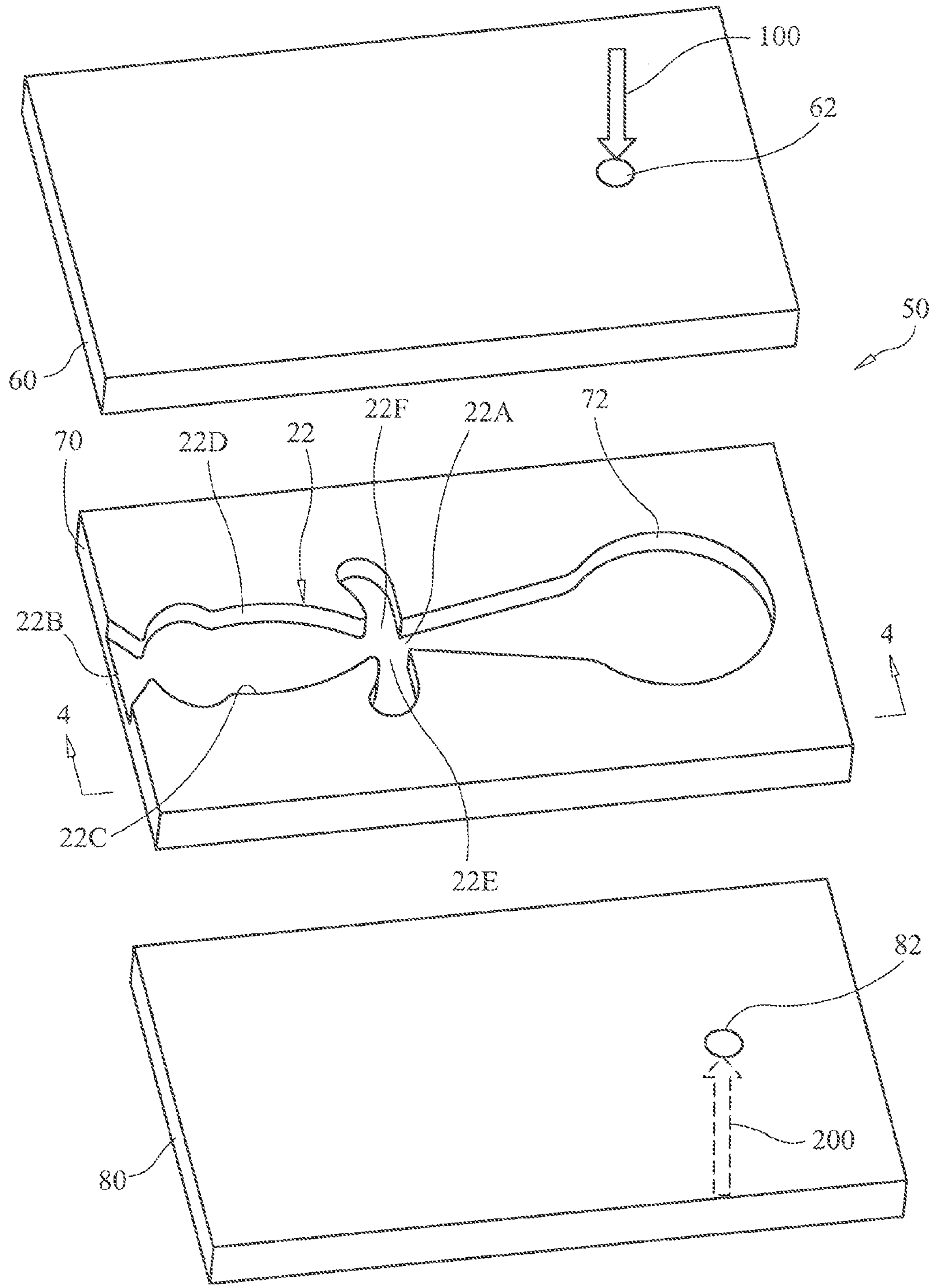
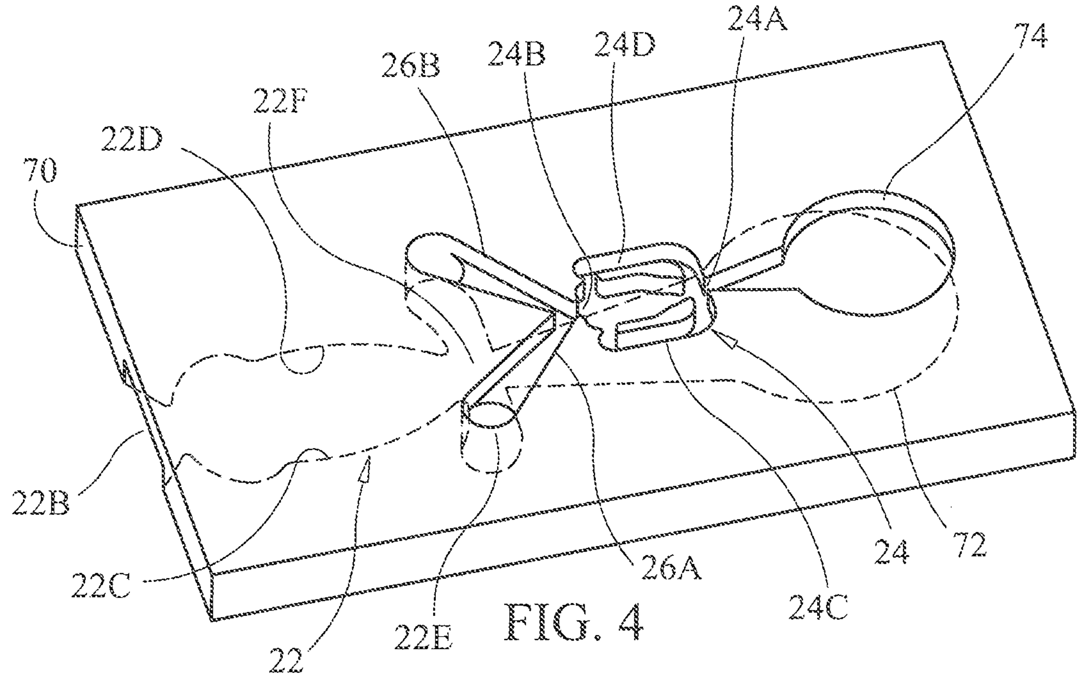
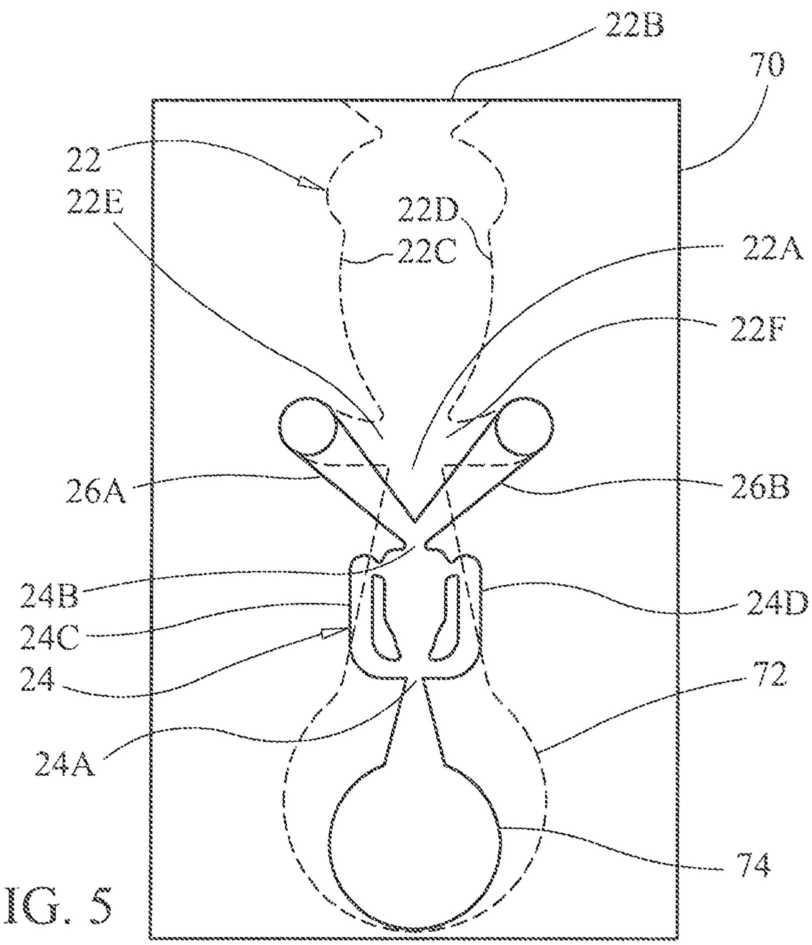


FIG. 3



24A
74
26B
24B
24D
22F
22D
70
22B
22C
22
22E
26A
24C
24
72

FIG. 4



22B
70
22
22E
22D
22C
22A
22F
26A
26B
24B
24D
24C
24
72
24A
74

FIG. 5

FLUIDIC OSCILLATOR HAVING DECOUPLED FREQUENCY AND AMPLITUDE CONTROL

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

The invention was made by an employee of the United States Government and may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

CROSS-REFERENCE TO RELATED PATENT APPLICATION

This application is related to co-pending U.S. patent application Ser. No. 13/786,713, titled "Fluidic Oscillator Array for Synchronized Oscillating Jet Generation," filed on the same day as this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to fluidic oscillators. More specifically, the invention is a fluidic oscillator having frequency control features that allow the oscillator's frequency to be controlled independently of the oscillator's mass flow rate or amplitude.

2. Description of the Related Art

In the 1900s, fluidic oscillators were developed for use as logical function operators. More recently, fluidic oscillators have been proposed for use as active flow control devices where an oscillator's jet output is used to control a fluid flow (e.g., gas or liquid). FIGS. **1**A-**1**C schematically illustrate the basic operating principles of a fluidic oscillator. Briefly, fluid flow **100** enters a fluidic oscillator **10** at its input **10**A and attaches to either sidewall **12** or **14** (e.g., right sidewall **14** in the illustrated example) due to the Coanda effect as shown in FIG. **1**A. A backflow **102** develops in a right hand side feedback loop **18**. Backflow **102** causes fluid flow **100** to detach from right sidewall **14** (FIG. **1**B) and attach to left sidewall **12** (FIG. **1**C). When fluid flow **100** attaches to left sidewall **12**, a backflow **104** develops in left hand side feedback loop **16** which will force fluid flow **100** to switch back to its initial state shown in FIG. **1**A. As a result of this activity, fluid flow **100** oscillates/sweeps back and forth at the output **10**B of oscillator **10**.

For conventional fluidic oscillators, the frequency of the oscillations is directly dependent on the supply pressure and hence mass flow rate (or amplitude) of the oscillator. However, for practical applications, it is highly desirable to decouple the frequency and amplitude of the oscillator so that the frequency of the oscillator could be controlled independently of its amplitude. A frequency-decoupled fluidic oscillator could thus deliver desired mass flow rates without changing the frequency or could deliver desired frequency oscillations at desired mass flow rates.

BRIEF SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a fluidic oscillator having frequency control features.

Another object of the present invention is to provide a fluidic oscillator whose frequency is independent of the oscillator's mass flow rate or amplitude.

Still another object of the present invention is to provide a method of decoupling frequency control from amplitude control in a fluidic oscillator.

Other objects and advantages of the present invention will become more obvious hereinafter in the specification and drawings.

In accordance with the present invention, a fluidic oscillator having independent frequency and amplitude control includes a fluidic-oscillator main flow channel having a main flow inlet and a main flow outlet. The main flow channel has a first control port and a second control port disposed at opposing sides thereof. The main flow channel defines a first volume between the main flow inlet and the main flow outlet. A fluidic-oscillator controller has an inlet and outlet with a second volume being defined between its inlet and outlet. The first volume defined by the main flow channel is greater than the second volume defined by the controller. A flow diverter coupled to the outlet of the controller defines a first fluid flow path from the outlet to the first control port and defines a second fluid flow path from the outlet to the second control port.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A-**1**C schematically illustrate the operating principles of a fluidic oscillator in accordance with the prior art;

FIG. **2** is a schematic illustration of a fluidic oscillator having independent frequency and amplitude control in accordance with an embodiment of the present invention;

FIG. **3** is an exploded perspective view of a multi-layer fluidic oscillator having independent frequency and amplitude control in accordance with an embodiment of the present invention;

FIG. **4** is an isolated perspective view of the fluidic-oscillator controller portion of the present invention; and

FIG. **5** is a plan view of the fluidic-oscillator controller portion of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring again to the drawings and more specifically to FIG. **2**, a fluidic oscillator for generating an oscillating jet whose frequency is controlled independently of the jet's mass flow rate (or amplitude) in accordance with an embodiment of the present invention is illustrated schematically and is referenced generally by numeral **20**. Fluidic oscillator **20** includes a main oscillating-flow channel **22**, a frequency-controlling fluidic oscillator **24** (or fluidic-oscillator controller as it will also be referred to herein), and a fluid flow diverter **26** fluidically coupling frequency-controlling fluidic oscillator **24** to main flow channel **22**.

Main oscillating-flow channel **22** is configured as the main flow channel of a conventional fluidic oscillator, but does not have conventional feedback loops coupled thereto. That is, channel **22** only has an inlet **22**A for receiving a (main or amplitude-controlling) fluid flow **100**, an outlet **22**B through which the fluid flow will exit as an oscillating jet **110**, opposing Coanda surfaces **22**C/**22**D, and opposing-side control ports **22**E/**22**F. The particular shape/configuration of inlet **22**A, outlet **22**B, Coanda surfaces **22**C/**22**D, and ports **22**E/**22**F are not limitations of the present invention. The volume V_{22} of main oscillating-flow channel **22** (i.e., between inlet **22**A and outlet **22**B) is known.

Frequency-controlling fluidic oscillator **24** is configured as a conventional fluidic oscillator having an inlet **24**A for receiving a (frequency controlling) fluid flow **200** and an outlet **24**B through which the fluid flow will exit as an oscillating jet **210**. Fluidic oscillator **24** will also include conventional feedback loops terminating in feedback and control ports (not shown) used in the creation of oscillating jet **210** as would be understood in the art. The volume V_{24} of fluidic oscillator **24** is known and should be smaller than the volume V_{22} of main oscillating-flow channel **22**. For reasons that will be explained further below, the smaller volume of fluidic oscillator **24** ensures that the mass flow rate (amplitude) of fluidic oscillator **24** is less than that of main oscillating-flow channel **22**.

Fluid flow diverter **26** is a fluid-flow splitting device used to direct oscillating jet **210** in an alternating fashion to control ports **22**E and **22**F of main oscillating-flow channel **22**. The frequency of oscillating jet **210** serves as the frequency control for main oscillating-flow channel **22** producing oscillating jet **110**. Since frequency-controlling fluidic oscillator **24** only needs to disturb the flow moving through channel **22** (i.e., analogous to disruptions provided by feedback loops in conventional fluidic oscillators), a relatively small mass flow through oscillator **24** is all that is required. In general, the smaller mass flow for frequency control is achieved when the volume V_{22} is at least twice as large as the volume V_{24}. However, it is to be understood that the volume differential between main oscillating-flow channel **22** and fluidic oscillator **24** can be tailored for a specific application without departing from the scope of the present invention.

A variety of approaches can be used to construct a frequency-controlled fluidic oscillator **24** in accordance with the present invention. By way of example, a layered-construction fluidic oscillator **50** will be explained herein with simultaneous reference to FIGS. **3-5** where common reference numerals are used in the various views. Fluidic oscillator **50** is constructed from three layers/panels **60**, **70**, and **80**, where panels **60** and **80** sandwich panel **70**. Panels **60** and **80** are essentially covers for oscillator **50** with each of panels **60** and **80** having a respective fluid-flow inlet hole **62** and **82** formed therethrough.

In general, panel **70** has the main oscillating-flow channel's shape/volume formed on one face thereof and the frequency-controlling fluidic oscillator's shape/volume formed on the opposing face thereof. When panels **60** and **80** sandwich panel **70**, the main oscillating-flow channel and frequency-controlling fluidic oscillator of oscillator **50** are formed. The present invention's fluid flow diverter is formed in panel **70**. More specifically, one face of panel **70** defines a plenum region **72** that receives incoming fluid flow **100** (i.e., the main or amplitude-controlling fluid flow) via inlet hole **62**. Main oscillating-flow channel **22** has its inlet **22**A in fluid communication with plenum region **72**. Control ports **22**E/**22**F are disposed on either side of main oscillating-flow channel **22**. As mentioned above, the particular shape/configuration of main oscillating-flow channel **22** is not a limitation of the present invention. The opposing face of panel **70** defines a plenum region **74** (visible in FIGS. **4** and **5**) that receives incoming fluid flow **200** (i.e., the frequency controlling fluid flow) via inlet hole **82**. Frequency-controlling fluidic oscillator **24** has its inlet **24**A in fluid communication with plenum region **74**. As would be understood in the art, fluidic oscillator **24** defines conventional feedback loops **24**C and **24**D.

Diverter **26** is in fluid communication with outlet **24**B of frequency-controlling fluidic oscillator **24** and control ports **22**C/**22**D of main oscillating-flow channel **22**. More specifically, a first flow path **26**A formed in and through panel **70** is directed from outlet **24**B to control port **22**E, while a second flow path **26**B formed in and through panel **70** is directed from outlet **24**B to control port **22**F. In this way, the frequency-controlling oscillating jet **210** is supplied to control ports **22**E/**22**F in an alternating fashion in accordance with the frequency of oscillating jet **210**.

The advantages of the present invention are numerous. Frequency control of the fluidic oscillator's main oscillating-flow channel is decoupled from its amplitude. In this way, a desired mass flow rate (i.e., through the main oscillating-flow channel) can be delivered without changing the frequency thereof, or the frequency can be changed while maintaining a particular mass flow rate (i.e., through the main oscillating-flow channel). The approach is simple and requires no moving parts.

Although the invention has been described relative to specific embodiments thereof, there are numerous variations and modifications that will be readily apparent to those skilled in the art in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A fluidic oscillator having independent frequency and amplitude control comprising:

a fluidic-oscillator main flow channel having a main flow inlet configured to receive an amplitude controlling fluid flow and a main flow outlet, said main flow channel having a first control port and a second control port disposed at opposing sides thereof, said main flow channel defining a first volume between said main flow inlet and said main flow outlet;

a fluidic-oscillator controller having an inlet configured to receive a frequency controlling fluid flow and an outlet, wherein a second volume is defined between said inlet and said outlet, and wherein said first volume is greater than said second volume; and

a flow diverter coupled to said outlet of said controller, said first control port, and said second control port, said flow diverter defining a first fluid flow path directed from said outlet only to said first control port and defining a second fluid flow path directed from said outlet only to said second control port,

wherein said amplitude controlling fluid flow controls an amplitude of a fluid flow through said main flow channel and said frequency controlling fluid flow controls a frequency of said fluid flow through said main flow channel, and wherein said amplitude controlling fluid flow is independent of said frequency controlling fluid flow.

2. A fluidic oscillator as in claim **1**, further comprising a first plenum in fluid communication with said main flow inlet and a second plenum in fluid communication with said inlet of said controller.

3. A fluidic oscillator as in claim **2**, wherein said main flow channel and said first plenum are formed using a first panel and a second panel, wherein said controller and said second plenum are formed using said second panel and a third panel, and wherein said flow diverter is formed using said second panel.

4. A fluidic oscillator as in claim **1**, wherein said first volume is at least two times greater than said second volume.

5. A fluidic oscillator as in claim **1**, wherein said main flow channel, said flow diverter, and said controller are formed using a layered construction.

6. A fluidic oscillator having independent frequency and amplitude control, comprising:

a fluidic-oscillator main flow channel having only a main flow inlet configured to receive an amplitude controlling fluid flow, a main flow outlet, a first control port, and a second control port, wherein said first control port and said second control ports are disposed at opposing sides of said main flow channel, said main flow channel defining a first volume between said main flow inlet and said main flow outlet;

a fluidic-oscillator controller having an inlet configured to receive a frequency controlling fluid flow and an outlet, wherein a second volume is defined between said inlet and said outlet, and wherein said first volume is greater than said second volume;

and a flow diverter coupled to said outlet of said controller, said first control port, and said second control, said flow diverter defining a first fluid flow path directed from said outlet only to said first control port and defining a second fluid flow path directed from said outlet only to said second control port,

wherein said amplitude controlling fluid flow controls an amplitude of a fluid flow through said main flow channel and said frequency controlling fluid flow controls a frequency of said fluid flow through said main flow channel, and

wherein said amplitude controlling fluid flow is independent of said frequency controlling fluid flow.

7. A fluidic oscillator as in claim **6**, further comprising a first plenum in fluid communication with said main flow inlet and a second plenum in fluid communication with said inlet of said controller.

8. A fluidic oscillator as in claim **7**, wherein said main flow channel and said first plenum are formed using a first panel and a second panel, wherein said controller and said second plenum are formed using said second panel and a third panel, and wherein said flow diverter is formed using said second panel.

9. A fluidic oscillator as in claim **6**, wherein said first volume is at least two times greater than said second volume.

10. A fluidic oscillator as in claim **6**, wherein said main flow channel, said flow diverter, and said controller are formed using a layered construction.

* * * * *